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ABSTRACT

This study investigated the effects of central control of mathematics content or examinations on classroom practice. Data from Population B of the Second International Mathematics Study was used to examine United States, British Columbia, and Ontario teachers' responses to questions concerning the amount of agreement among teachers about which mathematics topics to teach, teachers' reasons for deciding what to teach, and teachers' reasons for deciding how to teach. Results are discussed in two parts: (1) the results of the curriculum and policy analysis are presented to provide a context for the quantitative analysis of the effects of central control, and (2) quantitative analysis shows that where there is central control, there is more agreement among teachers on what principal mathematical content to teach. British Columbia teachers exhibited the most agreement, followed by AP Calculus, Ontario, and Non-AP Calculus. Teachers indicated they teach topics because they are in the syllabus or on an external examination. By contrast, the data on teachers' decisions on how to teach reveal that the instruments of central control are less influential. (MDH)

The Effects of Central Control on Classroom Practice

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Paper presented at Session 25.21, AERA 1993

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Objective

Two recent calls for school reform propose different solutions to the problem of low student mathematics achievement in the United States. The solution proposed by the United States Department of Education (1991) calls for national examinations for high school seniors. The other solution, proposed by the mathematical and scientific community (Mathematical Association of America, 1991; National Council of Teachers of Mathematics [NCTM], 1989; National Research Council [NRC], 1989), calls for school districts to adopt the NCTM's *Curriculum and Evaluation Standards*. These two calls reflect different perceptions of mathematics teaching.

Proponents of national examinations want to effect change from the top down by directing teachers to teach particular content for a specific level of student achievement. The mathematical and scientific community takes the opposite view: instruction must be reformed from the bottom up. Curriculum reform must be a grass-roots effort that involves teachers from the outset because teachers act as "curriculum filters"--ultimately they decide what mathematics to teach and how to teach it (e.g., Holmes Group, 1986; NCTM, 1989; NRC, 1989).

The potential success of these solutions largely depends on the reasons why teachers teach what they do. If teachers teach mathematics content because a syllabus or external examination directs them to, then a national examination will have the effects its proponents claim. On the other hand, if teachers indeed are curriculum filters, then grass-roots reform will produce the effects its proponents claim.

The objective of this study is to investigate how central control of mathematics content (curriculum) or standards (examinations) affect classroom practice. Do teachers teach particular mathematical content because the syllabus or examination directs them to, or do they independently decide what mathematics to teach? Does the syllabus or examination tell them how to teach mathematics, or do they use their own judgment in selecting particular teaching methods? Investigating these questions makes it possible to predict the likely effects of establishing national examinations and grass-roots curriculum reform.

Perspective & Data Source

To investigate this question, Population B data collected as part of the Second International Mathematics Study (SIMS) were used. These data are from: British Columbia, Ontario, and the United States. Population B was defined for British Columbia as 12th-grade students enrolled in Algebra 12; for Ontario, as students enrolled in two or more grade 13 mathematics courses (Calculus, Relations and Functions, and Algebra); and for the United States, as 12th-grade students taking pre-college mathematics. US classes included Advanced Placement (AP) Classes and Non-AP Classes which were examined separately.

The perspective for the current study is, by necessity, framed by the perspective used in SIMS. (For details see Travers & Westbury 1988, 1989.) For SIMS, an international committee developed a test item pool that included questions on College (Advanced) Algebra, Analytic Geometry, Trigonometry, and Calculus. Another

committee developed classroom process questionnaires that asked whether specific topics from these areas were taught and how they were taught. In developing these instruments, the authors intended to produce instruments that *overall*, fit each system equally well. Thus, as Westbury points out (1992), we must fit each system and course into the SIMS framework before we can analyze the data meaningfully.

Methods

This study naturally divides into two parts: (a) curriculum and policy analysis, which matches SIMS questionnaires to course content and examines the extent of central control; and (b) quantitative analysis of teachers' reasons for instructional decisions. For the curriculum analysis, SIMS questionnaires were matched to course content by comparing the questionnaire topics to the published course descriptions. The accuracy of these judgments was then checked by evaluating how frequently the topics in each questionnaire were taught. For the policy analysis, the level of central control in each system (British Columbia, Ontario, AP Classes, and Non-AP Classes) was judged by examining system descriptions submitted for SIMS.

There are three components to the quantitative analysis of the SIMS data: (a) computing the amount of agreement among teachers about which topics to teach, (b) analyzing teachers' reasons for deciding what topics to teach, and (c) analyzing teachers' reasons for deciding how to teach selected topics. For (a), to analyze the agreement among teachers, the distributions of the percentages of teachers who agreed or disagreed on teaching each course topic were compared. For (b) and (c), in SIMS, teachers who taught a particular topic or used a particular representation were asked if they did so because it was: (a) in the textbook, (b) in the syllabus or on an external examination, (c) well known to them, (d) easy to teach, (e) easy for students to understand, (f) enjoyed by students, (g) related to prior mathematics, or (h) useful for later study of mathematics. Teachers who did not were to indicate why not, choosing from the negatives of the above reasons. The means and frequencies of these responses were compared.

Results

The results are discussed in two parts. First, the results of the curriculum and policy analysis are presented to provide a context for the quantitative analysis of the effects of central control.

Curriculum and Policy Analysis

Taken together, the pool of topics contained in the Population B questionnaires was designed to fit all the systems in SIMS equally well (Travers & Westbury, 1989). Of course, this means that some questionnaires fit some courses better than others, but *overall* they fit equally well. Consequently, the first step is to match the topics in SIMS questionnaires to the content of the courses in each system. If most of them are included, then the questionnaire contains *principal* content. If few topics are included, then the questionnaire contains *supporting* content. This distinction allows further examination of whether teachers' reasons for instructional decisions differ for prescribed mathematics (principal content) and supplemental mathematics (supporting content).

Using the descriptions supplied by national and provincial committees, it was judged that (a) British Columbia and AP Calculus Classes have centrally controlled content and standards, (b) Ontario classes have centrally controlled content and locally controlled standards, and (c) Non-AP Classes have locally controlled content and standards. (See Table I.)

		Control of Standards: Central	Control of Standards: Local
Control of Content	Central	US AP Calculus Classes (APC) British Columbia Algebra 12 (CBC)	Ontario Grade 13 (ONT)
	Local		US Non-AP Calculus Classes (NAP)

Table 1. Control of Content and Standards for Population B in British Columbia, Ontario, and the United States.

Although AP Calculus and British Columbia classes appear to function under similar control structures, there is a fundamental, important difference between them. Because colleges and universities award credit based on the results of the AP examination, the syllabi and examinations must meet the approval of university mathematicians. Thus, although the AP Calculus Development Committee does include classroom teachers, they have very little say in the syllabi or examinations.

In British Columbia, the Ministry of Education approves course textbooks and publishes curriculum guides that specify the content in considerable detail. In contrast to AP Calculus, even though the Ministry determines the curriculum, the committees that write the curriculum guides are composed almost entirely of classroom teachers. The Ministry nominates teachers to serve on these committees and it also invites the British Columbia Association of Mathematics Teachers (BCAMT) to nominate other members (David Robitaille, personal communication, 13 February 1992.). Consequently, the curriculum guides bear not only the imprimatur of the Ministry, but they also bear the imprimaturs of the *BCAMT and other classroom teachers.*

Furthermore, the geography of British Columbia significantly enhances teacher involvement. British Columbia has a relatively small population (2.5 million in 1981) concentrated in two metropolitan areas, Vancouver (1.2 million) and Victoria (0.2 million), about eighty kilometers (50 miles) apart. Consequently, there are about 2,000 secondary mathematics teachers concentrated in a relatively small area. Thus, even though the writing committees are small (about twelve members each), the number of teachers serving on curriculum-writing committees for the different secondary school courses represent a relatively large proportion of BC classroom teachers. Overall, this makes it easy to communicate the articulated curriculum because: the Ministry is nearby, most schools are relatively close to one another, there are relatively few teachers, and those teachers know one another from the BCAMT or from living and working near each other.

The small population of British Columbia contributes to the sense of curriculum ownership in another way. Because the market for textbooks is small, few publishers produce texts for the province. At the time of SIMS, only four textbooks were approved for Algebra 12, and three of those were used by over 95% of the teachers. In British Columbia the Ministry mandates a curriculum, classroom teachers and the BCAMT write the curriculum guides that articulate the curriculum, the "gospel" of the articulated curriculum spreads throughout the province, and three Ministry-approved textbooks

capture the market. In short, BC teachers "own" their curriculum in a very different sense than AP Calculus teachers.

Quantitative Analysis

Figure 1 shows the distributions of the percentages of teachers who agreed either to teach a topic or not.[1] Generally, where there is more central control, there is more agreement between teachers on what principal mathematical content to teach. British Columbia teachers exhibited the most agreement, followed by AP Calculus, Ontario, and Non-AP Calculus. For supporting content, a similar pattern emerged, except that a substantial minority of teachers from Non-AP Calculus Classes, Ontario, and AP Calculus Classes *independently elected* to teach particular topics.

Figure 2 shows the reasons teachers reported for *why* they taught particular topics. These are reported as the percentage of teachers who reported each reason. Teachers *do* teach topics because they are in the syllabus or on an external examination (BC, AP Calculus and Ontario). Non-AP Calculus teachers follow the textbook as a *de facto* syllabus. Teachers do not teach principal content because it is easy for student to understand, enjoyed by students, or easy to teach (Figure 3).

Although not shown, the instruments of central control (syllabus, examination, and text) are the most frequently cited reasons for *not* teaching particular topics. On the other hand, the data also show that teachers *are curriculum filters*. They choose to teach mathematics because: it is useful for later study, it is well known to them, or it is related to prior mathematics. This is even more evident in the data for supplemental content (Figure 4).

By contrast, the data on teachers' reasons for how to teach (Figure 5) reveal that the instruments of central control are less influential.[2] Teachers choose interpretations that are well known, easy for students to understand, useful later, or related to prior mathematics. As we might expect, they do not use interpretations that are not in the syllabus, external examination, textbook, but they do not use interpretations that are unrelated to prior mathematics or difficult for students to understand.

Policy Implications

Teachers do teach towards an examination yet they act as curriculum filters. This suggests that central examinations and grass-roots curriculum reform *in tandem* will be more effective than either alone. How can this apparent dichotomy be reconciled? British Columbia offers one solution.

Because the Ministry works closely with teachers to develop curriculum guides, mathematics teachers in British Columbia share a common vision of what school mathematics is. Thus, they teach the same content and have little need to cover prerequisite mathematics (unlike AP Calculus, for example). They "filtered" the curriculum when they wrote the curriculum guides. Furthermore, this study suggests that central control is more effective when it is more "local." Certain geographic features of British Columbia enhanced teachers' sense of curriculum ownership: the ministry that mandated the curriculum was nearby; BC has a small population and hence relatively few teachers; and the population is centered in two, relatively close metropolitan areas. Although it might not be possible to replicate all of these conditions in every state, none of them could be replicated at the national level--the United States is too vast and too populous.

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[1]The figures can be found at the end of this paper.

[2]These data are reported as gross responses instead of percentages because it is difficult to deermine how many teachers used each interpretation.

As this study has shown, teachers cite a variety of mathematical and pedagogical reasons for teaching content. Therefore, if new curricula include new mathematical topics, then teachers need to learn more mathematics--they must learn these new topics, see how they relate to prior mathematics, and see how they are useful in later mathematics. If a new curriculum includes new interpretations of mathematical concepts, then teachers need more understanding of the pedagogy--they must understand these interpretations deeply, be shown that they will promote better student understanding, and see how these interpretations are useful for later mathematics.

Thus, effective school mathematics reform is not a question of either examinations or grass-roots curriculum reform--deciding what mathematics to teach and how to teach it is a complex process. If we are to improve student mathematics achievement, we must recognize the central role teachers play in transmitting the curriculum.

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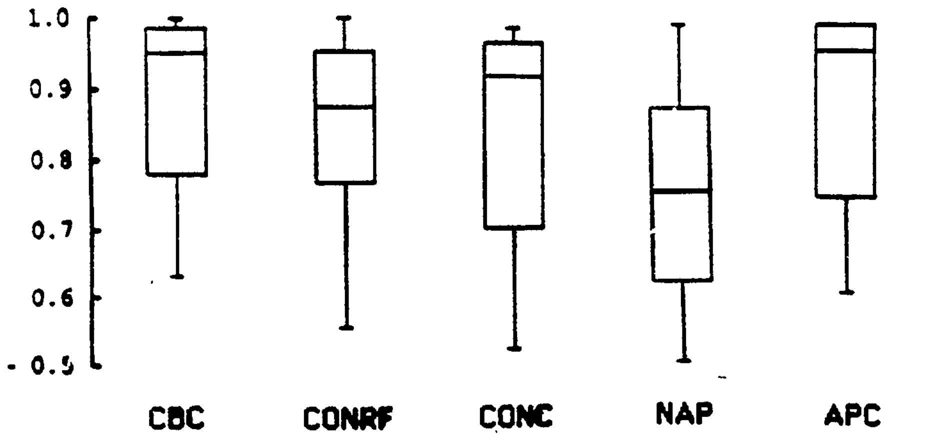
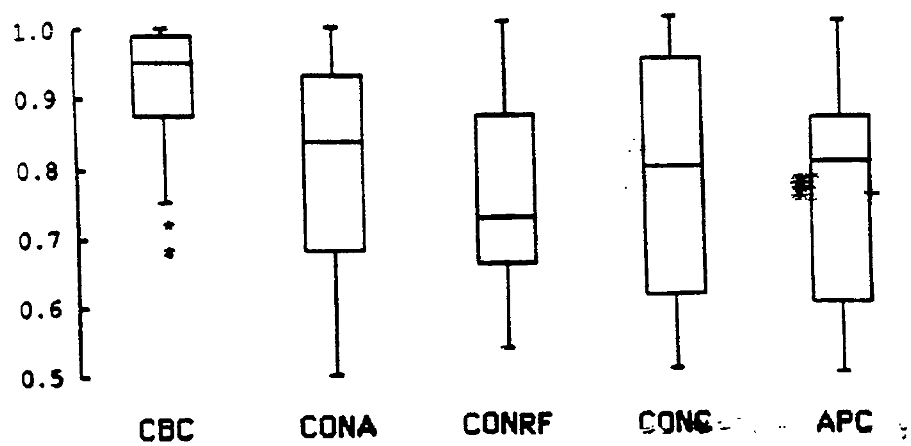
Figure 1. Distributions of the Agreement Among Teachers About What Topics To Teach



(a) Principal Content



(b) Supporting Content

Key:	CBC	British Columbia Algebra 12 Classes
	CONRF	Ontario Relations & Functions Classes
	CONC	Ontario Calculus Classes
	CONA	Ontario Algebra Classes
	NAP	United States non-AP Calculus Classes
	APC	United States AP Calculus Classes

Figure 2. Most Frequently Cited Reasons for Teaching Principal Content.

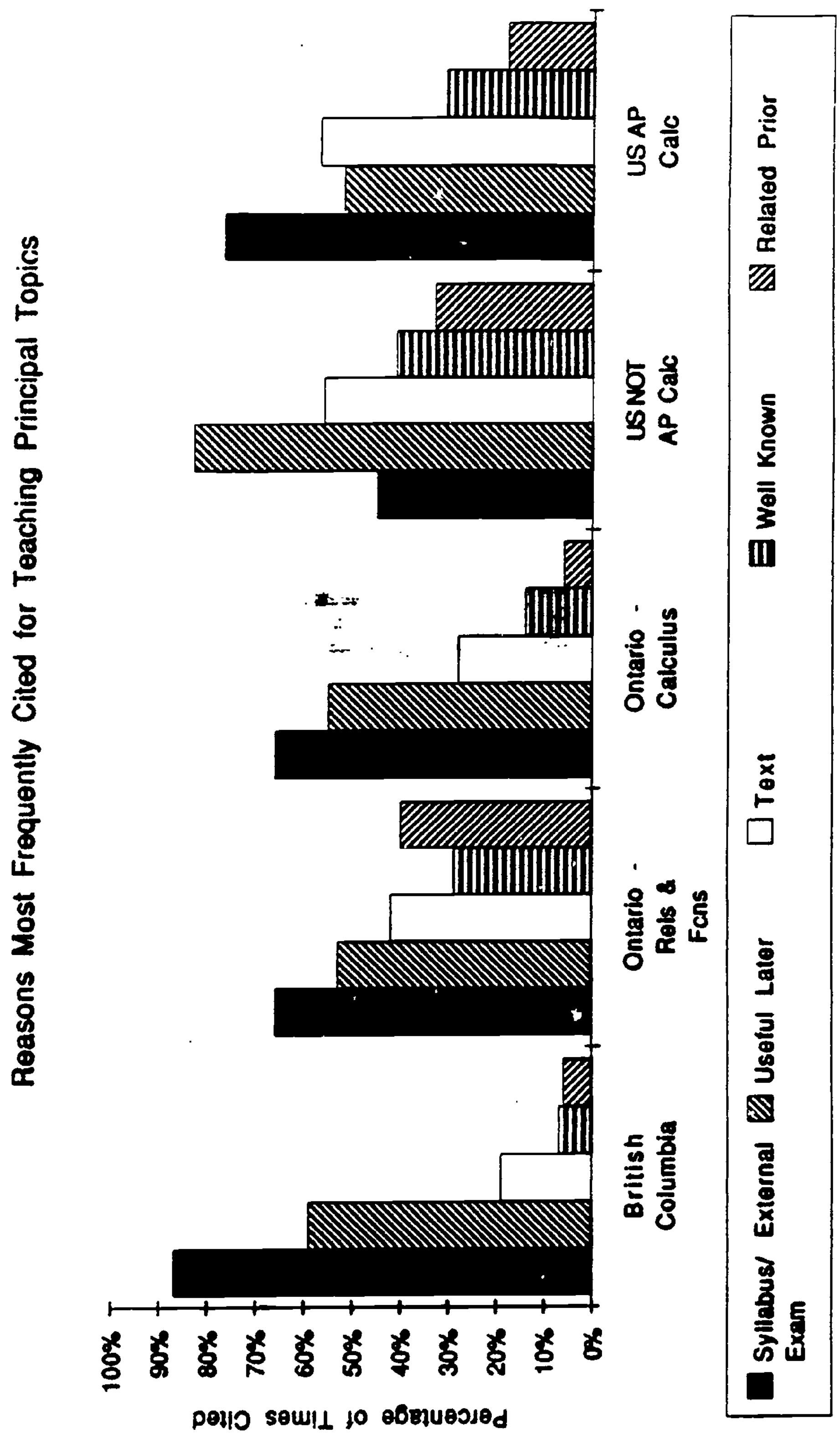


Figure 3. Least Frequently Cited Reasons for Teaching Principal Content.

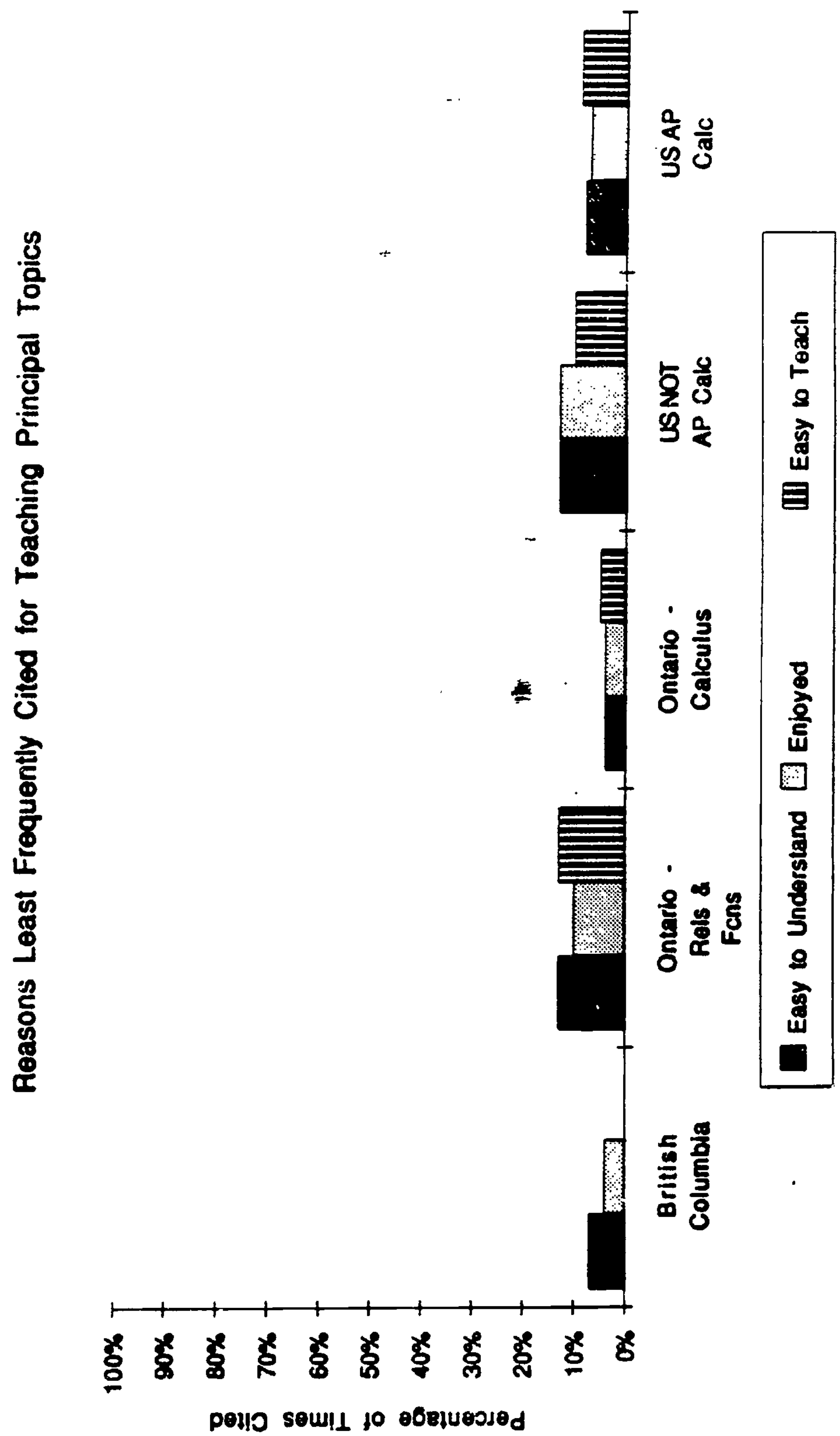


Figure 4. Most Frequently Cited Reasons for Teaching Supporting Content.

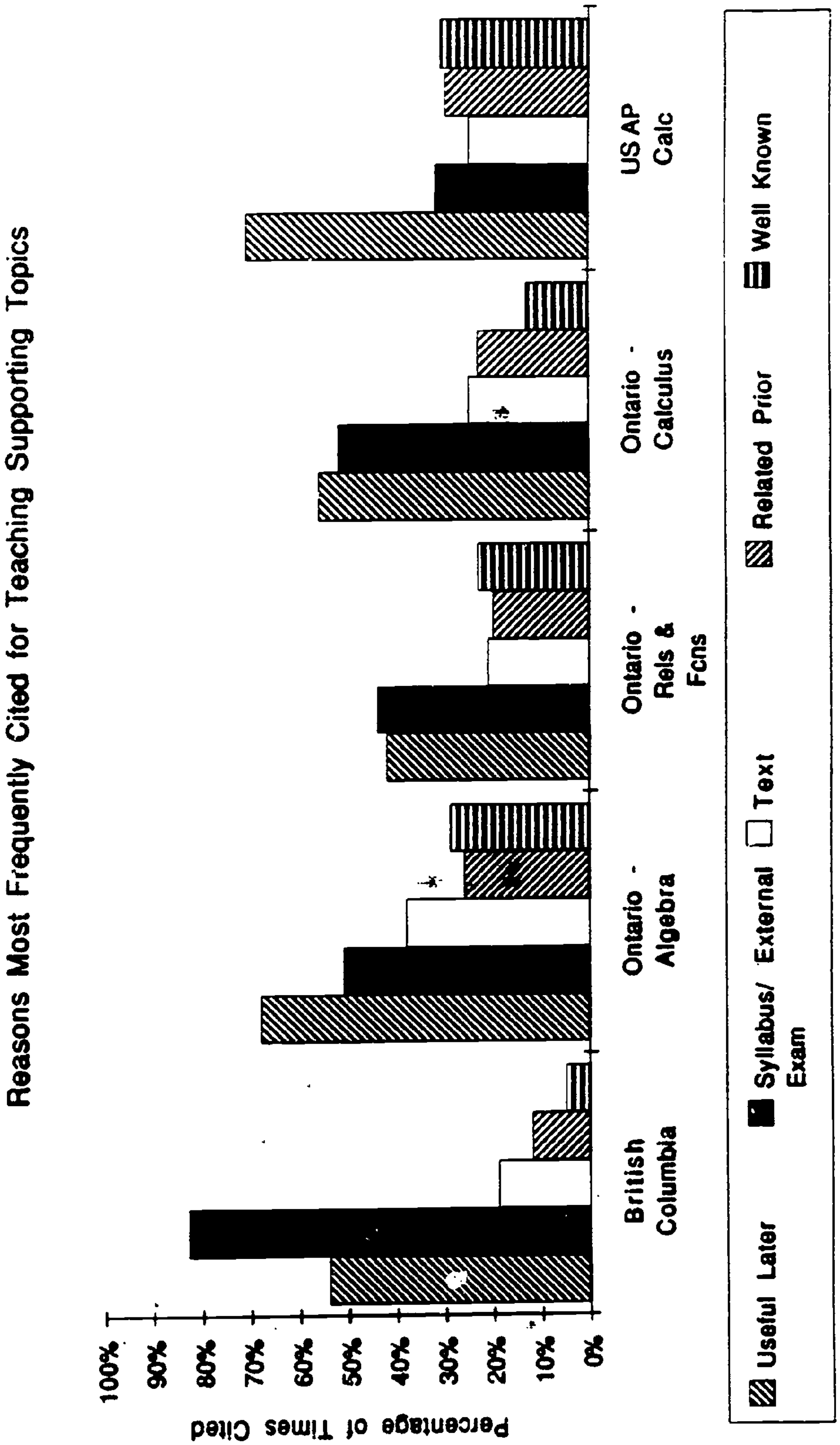


Figure 5. Most Frequently Cited Reasons for Using Particular Interpretations.